Development of a Seasonal Fire Severity Forecast for the Contiguous US: Weather Forecast and Validation.

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1. INTRODUCTION

The Scripps Experimental Climate Prediction Center (ECPC) has been making experimental, near real-time seasonal global forecasts since Sept. 26, 1997 with the NCEP global spectral model (GSM) used for the reanalysis (Kalnay et al. 1996). Images of the ECPC forecasts, at daily to seasonal time scales, are provided on the world wide web (http://ecpc.ucsd.edu/ and digital forecast products are provided on the ECPC anonymous ftp site to interested researchers. These forecasts are increasingly being used to drive regional models at the ECPC and elsewhere as well as various application models.

7-day GSM forecasts are made everyday in order to provide general information to interested researchers as well as to develop the basic 1-day validating analysis (V1) described below. 12-week GSM forecasts are made once a week (every weekend when the greatest computer capacity is available). These 12-week forecasts are then archived into weekly averages, which can be further averaged into 3 monthly (4-week) averages and a seasonal (12-week) average. Because of limited archive capacity, we decided not to evaluate time scales of less than a week, at least initially.

The purpose of this talk is to describe the various biases and errors in the global forecasts, as well as the significant skill of the forecasts. Our next goal will be to compare these global forecasts to regional forecasts driven by the global forecasts in order to determine what additional information might be provided by the regional forecasts.

2. INITIAL AND VALIDATING ANALYSIS

The initial conditions for the GSM forecasts come from the NCEP Global Data Assimilation System (GDAS) operational analysis (L28T126), which are posted in a timely fashion on a rotating disk archive at NCEP.

Although the operational GDAS analyses are sufficient to start our GSM forecasts, they are not sufficient to evaluate the desired forecast variables. For example, only atmospheric state variables such as temperature, humidity, winds, surface pressure, and surface state variables such as soil moisture and snow, are available in the GDAS sigma files and surface files. Another file, the so-called flux file, developed from 6 hour forecasts with the medium range forecast (MRF) or Aviation model contains near surface information such as max, min 2 m temperature, humidity, 10 m winds, surface latent, sensible, radiative fluxes and top of atmosphere radiation fluxes, and precipitation. These flux files were more difficult to access initially and it was not until Mar. 15, 1998 that we were successful in getting the 4xdaily flux files to evaluate our forecasts. These operational flux files (referred to as VO here) then formed our basic validation data set until the NCEP fire (Sept. 27, 1999) at which point only 2xdaily flux files became available and adversely affected the daily averages we were making from the 4xdaily forecasts. Although we could have also used the NCEP reanalysis files to validate the model (and we did use these to develop preliminary climatologies before we had the aviation files), we were never able to access these files in as timely a manner as the aviation files.

In order to extend backward the validation forecast period to the time when we first started archiving initial states, to extend a consistent validation beyond the NCEP fire, and to have available in near real time validating observations, we ultimately decided to develop our own flux files. Therefore, for our main validation effort, we now use one-day forecasts made every day from 00 UTC analysis initial conditions. This 1-day forecast analysis validation set will hereafter be referred to as (V1).

3. EVALUATIONS

As an example of our evaluation, we show here the global and US forecast fire weather index (FWI), and a fire weather index, which is a nonlinear combination of weather variables). Roads et al. (2001a,c,d) and Chen et al. (2001) describe forecasts for other regions and other variables. Some of these other regions and variables are discussed in the talk.

The GSM seasonal forecast fire weather index (FWI), which basically reflects wind speed and relative humidity, is the inverse of the relative humidity and soil moisture and is relatively high in those regions of low soil moisture and relative humidity (Figs. 1a,b). Although variations in the FWI are also reflected by the wind speed, it does not include vegetation stress, which must somehow be related to soil moisture, and which is better incorporated in standard fire danger indices (See e.g. Roads et al. 2000). There is a tendency for the forecasts to have a negative bias (Figs. 1c,d), which can be traced to the tendency for the model to have relatively high relative humidity over the land regions and a negative wind bias. Still, seasonal forecast correlations (Figs. 1e,f) are high over much of the US, except for the front range of the Rocky Mountains. Globally the highest forecast correlations are found over most land regions with the major exceptions being the northwestern US, Africa, and South America regions. The correlation pattern resembles more the relative humidity correlation pattern (instead of the wind speed correlation pattern), indicating that it is the relatively accurate forecasts of relative humidity, more than windspeed, that provide some skill for the forecast FWI at long (seasonal) time scales

Fig. 2 shows temporal characteristics of global and US (land only) FWI variations. Like the soil moisture, there is a distinct interannual variation with lower FWI during the first part of the period and higher FWI during the latter part of the period (Figs. 2a,b). This variation is notable, despite there being a substantial bias in the FWI, especially with regard to the operational analysis (Figs. 2c,d). This bias is due mainly to the substantial bias in the relative humidity although the models weaker wind speed also contributes. By contrast, the forecast model standard deviations are substantially stronger than the analysis standard deviations especially over the US during the springtime (Figs. 2e,f). The normalized covariance is fairly significant and shows little seasonal variation (Figs. 2g,h) but strong intraseasonal variation, especially over the US and especially when using the 1-day forecasts (V1) to validate the seasonal forecasts.

4. DISCUSSION

In addition to the FWI shown here, evaluations for many additional near surface meteorological parameters have been made. In brief, many relevant near-surface meteorological parameters (including temperature, precipitation, soil moisture, relative humidity, wind speed are skillful at weekly to seasonal time scales over much of the US and in many global regions. Surface temperature forecasts are the most skillful, with ensemble seasonal forecast correlations of .7 for the US and .62 for the globe. Precipitation has much lower forecast skill, .3 over the US and .24 globally. Relative humidity is a bit more skillful at seasonal time scales with correlations over the US of .5 and .3 globally. Windspeed forecasts are more problematic with seasonal forecast skill of .3 over the US and .27 globally. FWI, which is a nonlinear combination of windspeed and relative humidity, has higher forecast skill, which presumably arises from contribution of the relative humidity as well as wind speed to the FWI.

Finally, soil moisture forecasts are skillful but show little skill beyond what is available from simply persisting the initial state. Nonetheless, the strong persistence of the soil moisture is presumably one of the controlling features on the ability of the model to make skillful seasonal forecasts of temperature and other variables, like FWI. It should in fact be noted that for all other variables, the model forecast skill is generally greater than persistence.

It should also be noted that forecast skill almost always increases with averaging length. This is due in part to the inclusion of skillful initial forecasts; however, even monthly forecasts with two-month lags are more skillful than corresponding weekly forecasts with similar lags, indicating the positive influence of time averaging here.

Even better weekly to seasonal forecasts can probably be made. For example, a number of recent improvements have been implemented in NCEP models, which may ultimately prove useful in increasing the forecast skill (see e.g. Hong and Leetma, 1999; Kanamitsu, personal communication). In that regard, it is our intention to eventually transition our forecast system to a more recent version of the NCEP model and to re-examine the skill in the new system. It should also be noted that a regional spectral model (see Juang and Kanamitsu, 1994; Chen et al. 1999, Anderson et al. 2000; Roads and Chen, 2000), with the same basic parameterizations as the GSM, is also being used to make higher resolution forecasts for specific regions. The forecast skill of the higher resolution forecast model will eventually be compared to the forecast skill of this global model as soon as we can obtain a similar number of high-resolution regional forecasts.

The GSM output is also being used to force regional models at other application centers as well as specific application models. For example, the GSM now forces a single column model, as well as an ocean model, which will eventually be coupled to the atmospheric model. Limited output products from the GSM and RSM are also being used for a wide variety of experimental applications.

5. ACKNOWLEDGEMENTS

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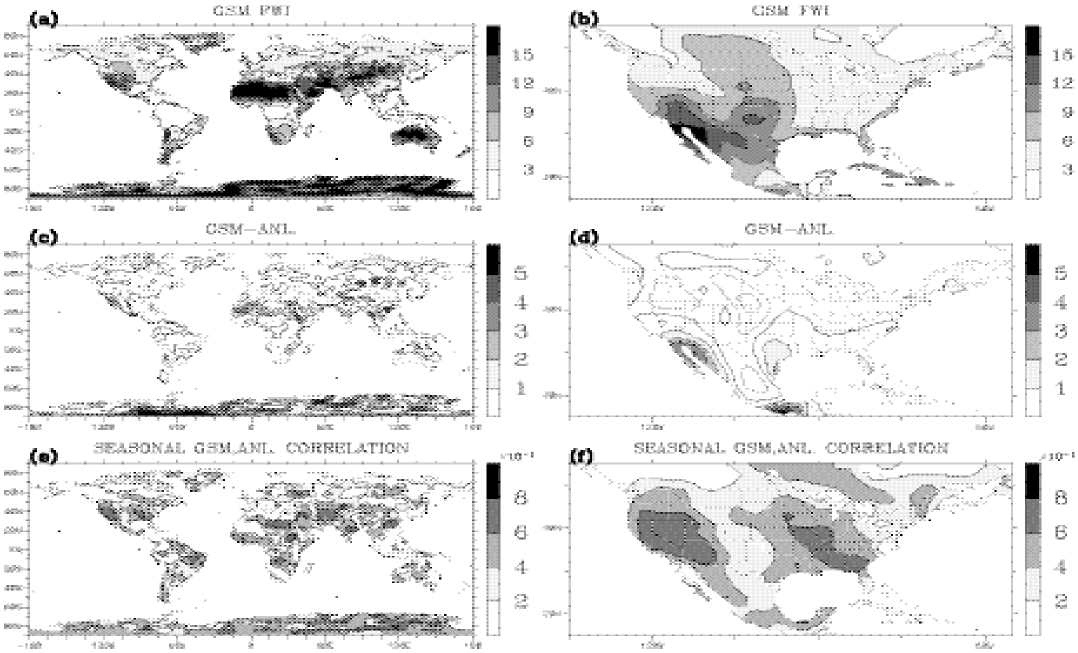

Fig. 1 FWI seasonal predictions (97/10-99/10; 104 forecasts): (a) GSM seasonal mean; (b) US focus; (c) GSM - V1 analysis mean; (d) US focus; (e) Global correlation [GSM, V1 analysis]; (f) US focus.

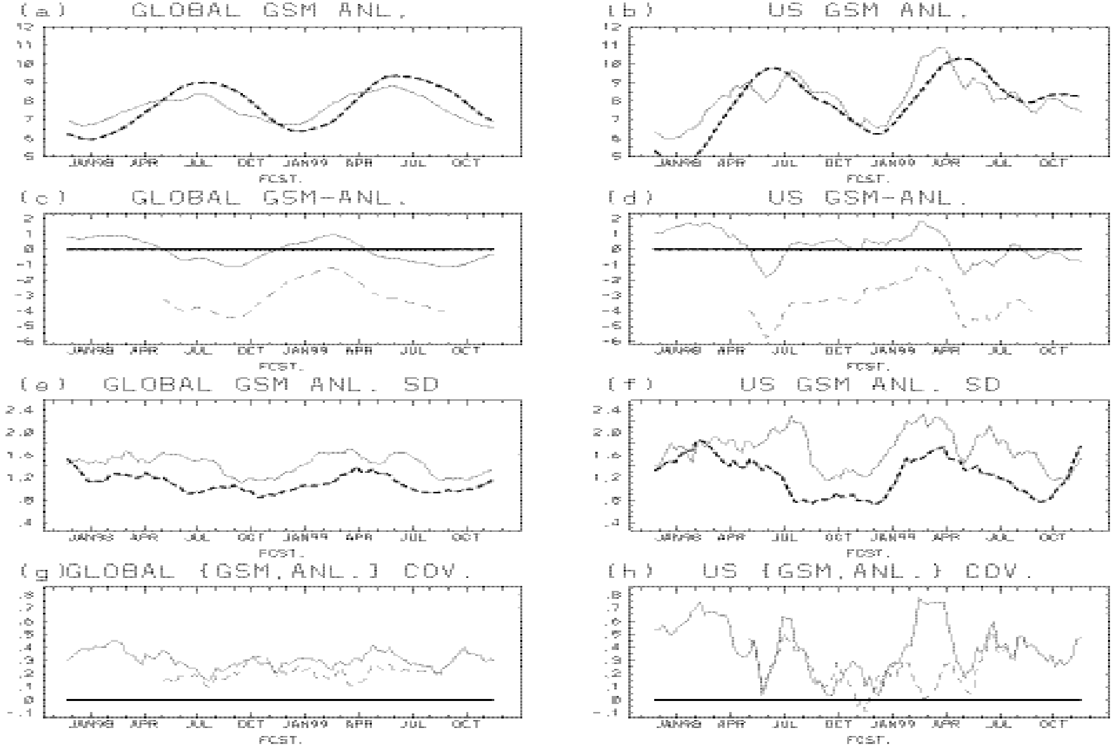

Fig. 2 FWI seasonal forecast temporal variations (97/10-99/10; 104 forecasts; smoothed by 5 forecast running mean). (a) Global, GSM (solid), V1 (dashed); (b) US; (c) Global GSM – V1 (solid), GSM-VO (dashed); (d) US; (e) Global GSM (solid), V1 (dashed) RMS; (f) US; (g) Global {GSM, V1} (solid), GSM, VO} (dashed), normalized seasonal covariance; (h) US.